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# Standard Specification for Laminated Architectural Flat Glass[1]

This standard is issued under the fixed designation C1172; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ($\varepsilon$) indicates an editorial change since the last revision or reapproval.

$\varepsilon^1$ NOTE—Editorial changes were made throughout in March 2011.

## 1. Scope

1.1 This specification covers the quality requirements of flat laminated glass consisting of two or more lites of glass bonded with an interlayer material for use in building glazing.

1.2 Depending on the number, thickness and treatment of lites, and the number and thickness of interlayers, the glass shall be laminated for applications including but not limited to safety security, detention, hurricane/cyclic-wind resistant, blast resistant, bullet resistant and sound reduction glazing applications. Laminated glass used in furniture applications is not included in this specification.

1.3 Optical distortion and the evaluation thereof are not currently within the scope of the standard. Mockups are recommended as a method to evaluate glass. (See Appendix X1.)

1.4 The dimensional values, except thickness designations, stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.5 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 Reference to these documents shall be the latest revision unless otherwise specified by the authority applying this specification.

2.2 *ASTM Standards:*[2]

C162 Terminology of Glass and Glass Products
C1036 Specification for Flat Glass
C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass
C1376 Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass
C1422 Specification for Chemically Strengthened Flat Glass
C1503 Specification for Silvered Flat Glass Mirror
E308 Practice for Computing the Colors of Objects by Using the CIE System
E1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
E1996 Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes
F1233 Test Method for Security Glazing Materials And Systems
F1642 Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
F1915 Test Methods for Glazing for Detention Facilities

2.3 *ANSI Standard:*
Z97.1 Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Tests[3]

2.4 *Federal Document:*[4]
CPSC 16CFR1201 Consumer Product Safety Commission Safety Standard for Architectural Glazing Materials

2.5 *National Institute of Justice (NIJ) Standard:*[5]
NIJ 0108.1 Ballistic Resistant Protective Materials

2.6 *UL Standards:*[6]
UL 752 Standard for Bullet Resisting Materials
UL 972 Standard for Burglary Resisting Glazing Materials

[1] This specification is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East West Hwy., Bethesda, MD 20814, http://www.cpsc.gov.

[5] Available from National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://www.ojp.usdoj.gov/nij.

[6] Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, http://www.ul.com.

## 3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology C162, Specifications C1036 or C1048, as appropriate.

3.1.2 *blemishes in flat glass*—Refer to Specifications C1036 or C1048, as appropriate.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adhesion chips*—See *fuse* .

3.2.2 *blow-in*—a separation of glass and interlayer at or close to the laminate edge caused by penetration of the autoclaving medium into the edge during manufacturing.

3.2.3 *boil (bubble)*—a gas pocket in the interlayer material or between the glass and interlayer.

3.2.4 *covered edge*—the peripheral area of the laminate covered by the channel or sash when installed.

3.2.5 *delamination*—a condition in which one or two of the lites of glass loses the bond between the glass lite and the interlayer.

3.2.6 *discoloration*—a visibly noticeable color change (from original) in the appearance of a material.

3.2.7 *distortion*—the inability to see an image clearly; the image is twisted out of natural shape.

3.2.8 *edge boil*—See *boil (bubble)*.

3.2.9 *exposed edge*—the peripheral area of the laminate exposed to the environment after installation.

3.2.10 *fuse*—a glass particle or crystalline material that is permanently bonded to a surface of a lite.

3.2.11 *hair*—a slender, pigmented filament from human or animal epidermis or other thread-like filament.

3.2.12 *inside dirt*—foreign material trapped inside the laminate.

3.2.13 *interlayer*—a layer or multiple layers of material acting as an adhesive between lites of glass which adds additional performance to the finished product, for example, impact resistance, solar control, acoustical insulation.

3.2.14 *laminated glass*—an assembly consisting of two or more lites of glass, conforming to Specification C1036 or C1048 that are bonded together by interlayer material.

3.2.15 *lint*—short fibers of yarn or fabric trapped within the laminate.

3.2.16 *lite or light*—a panel or sheet of glass or a panel or sheet of laminated glass.

3.2.17 *mismatch*—misalignment of the edges of two lites of glass, when laminated.

3.2.18 *nonsymmetrical*—a term used to describe the construction of a laminate comprised of different glass types or thickness, or both.

3.2.19 *offset*—glass lites that are intentionally not aligned in a laminate.

3.2.20 *rub*—abrasion of a glass surface producing a frosted appearance. Also known as a scuff.

3.2.21 *separation*—an area of the laminate that has become delaminated (see *delamination*).

3.2.22 *shiner*—an area on a glass edge that has not been ground or polished.

3.2.23 *short interlayer*—a condition of the laminate in which the interlayer does not extend to the edge.

3.2.24 *streak*—a noticeably visible directional blemish or discoloration on or in the laminated unit.

3.2.25 *symmetrical*—a term used to describe the construction of a laminate comprised of only one glass type and thickness.

3.2.26 *template*—a pattern used as a guide to define the overall size and shape of a cut lite.

3.2.27 *unlaminated area*—an area of the laminate that failed to laminate during the laminating process. This blemish may be discernible due to the textured appearance of the interlayer material.

## 4. Classification

4.1 *Type*—Laminated flat glass furnished under this specification shall be of the following types, as specified:

4.1.1 *Type I - Laminated Glass*—an assembly consisting of two or more lites of glass, conforming to Specification C1036 or C1048 that are bonded together by interlayer material.

4.1.2 *Type II - Laminated Safety Glass*—as defined in ANSI Z97.1 or CPSC 16CFR1201 or both. Two or more lites of flat glass, bonded by interlayer material. In the case of breakage, the interlayer serves to retain the glass fragments, limit the size of the opening and reduce the risk of cutting or piercing injuries.

4.2 *Application*—the following terms are designed to guide the user to the appropriate inspection charts and requirements. The glazing can usually, but not always be viewed in transmittance and reflectance.

4.2.1 *Laminated Vertical Glazing*—Glazing used in an installation in which the lower edge of the glazing is a maximum of 6 ft (1.8 m) above the walking surface. The glazing is usually vertical, however may also be sloping in or out from the vertical plane. The glazing can be approached within 10 ft (3 m) or less (if distance is greater than 10 ft (3 m) see *Laminated Overhead Glazing*). Interior decorative glazing will be judged according to laminated vertical glazing criteria.

4.2.2 *Laminated Overhead Glazing*—Glazing used in an installation in which the lower edge of the glass is more than 6 ft (1.8 m) above a walking floor level or cannot be approached within 10 ft (3 m). The glazing is usually sloping from the vertical plane, however may also be vertical. Sloped glazing is considered any glazing that slopes more than 15° from the vertical in any direction.

4.2.3 *Laminated Spandrel Glazing*—Glazing used in an installation in which the glazing is only viewed in reflection from the building's exterior. The glazing is usually installed vertically, however, may be at a slope to the vertical plane. Laminated spandrel glazing shall be inspected using the criteria of vertical or overhead laminated glazing. (See section 4.2.1 or 4.2.2) based upon installation as vertical or overhead glazing.

## 5. Ordering Information

5.1 Purchasers should select the preferred options permitted in this specification and include the following information in procurement documents:

5.1.1 Title, number, and date of this specification.

5.1.2 Type of laminated flat glass as referred to in this specification (see Section 4).

5.1.3 Edgework requirements (see 8.2).

5.1.4 Thickness requirements:

5.1.4.1 Thickness designation of each individual lite of glass to be used in the laminate,

5.1.4.2 Interlayer type and thickness designation, and

5.1.4.3 Overall nominal thickness of the laminate.

5.1.5 Nominal length and width of the laminate.

5.1.5.1 Blueprint, drawing, template, configuration specification, or other forms of information which detail overall size, configuration, and orientation.

5.1.6 Types of each individual lite of glass to be used in the laminate.

5.1.6.1 Color, tint, coating, decorative effect and strength of each individual lite of glass.

5.1.7 Color, tint and decorative effect of the interlayer.

5.1.8 The luminous transmittance of the laminate (see 7.11).

5.1.9 Safety standards or regulations to which the laminate must conform.

5.1.10 All other standards to which the laminate must conform.

5.2 *Packaging Requirements*—Glass packaging and protection will be standard manufacturer practice unless otherwise specified. Consult manufacturer before specifying.

## 6. Other Requirements

6.1 Annealed glass lites shall conform to the requirements of Specification C1036 for the incorporated glass type.

6.2 Chemically strengthened glass lites shall conform to the requirements of Specification C1422.

6.3 Heat strengthened or fully tempered glass lites shall conform to the requirements of Specification C1048.

6.4 Mirror glass lites shall conform to the requirements of Specification C1503.

6.5 Pyrolytic and vacuum deposition coated glass lites shall conform to the requirements of Specification C1376.

6.6 Solar and Optical property shall be as specified.

6.7 Solar Heat Gain Coefficient shall be as specified.

6.8 Spandrel glass lites shall conform to the requirements of Specification C1048 for the incorporated glass type.

6.9 Visible reflection shall be as specified.

6.10 Visible transmittance shall be as specified.

6.11 U-factor shall be as specified.

## 7. Test Methods

7.1 *Impact Test for Safety Glazing*—Test and interpret in accordance with ANSI Z97.1 or CPSC 16CFR1201, or both, as applicable.

7.2 *Test for Missile Impact and Cyclic Pressure* —Test and interpret in accordance with Test Method E1886 and Specification E1996.

7.3 *Test for Security Glazing*—Test and interpret in accordance with Test Method F1233.

7.4 *Test for Glazing Subject to Airblast Loading*—Test and interpret in accordance with Test Method F1642.

7.5 *Test for Detention Glazing*—Test and interpret in accordance with Test Method F1915.

7.6 *Test for Bullet Resisting Glazing*—Test and interpret in accordance with specified standards such as Test Method F1233, NIJ 0108.1, and Standard UL 752.

7.7 *Test for Burglary Resisting Glazing*—Test and interpret in accordance with specified standards such as, but not limited to: Test Method F1233, NIJ 0108.1, and UL 972.

7.8 *Overall Bow/Warp*—Place sample glass in a free-standing vertical position, with the longest edge resting on blocks at the quarter points. With the laminate in this position, place a straightedge across the concave surface, parallel to and within 1 in. (25.4 mm) of the edge, and measure the maximum deviation with a taper or feeler gage. A dial indicator may also be used.

7.9 *Size*—Measure length and width from edge to edge, including flares, mismatch, or offset (see 8.5).

7.10 *Visual Inspection*—All visual inspections shall be made with 20/20 vision (normal or corrected eye). The viewer shall look at the sample at an angle of 90° (perpendicular) to the surface using the following lighting unless otherwise specified: daylight (without direct sunlight) or other uniform diffused background lighting that simulates daylight, with a minimum luminance of 160 fc (1700 lx) measured at the surface of the glass facing the light source.

7.10.1 *Laminated Vertical Glazing*—Inspect glazing in the vertical position at a distance of 39 in. (1 m). If a blemish is readily apparent under these viewing conditions, refer to Table 1 for acceptable criteria.

7.10.2 *Laminated Overhead Glazing*—Inspect glazing in the vertical position at a distance of 10 ft (3 m). If a blemish is readily apparent under these viewing conditions, refer to Table 2 for acceptable criteria.

7.11 *Transmittance*—Using Practice E308, measure transmittance by illuminating each laminated specimen at normal incidence with light having the spectral composition of International Commission on Illumination (CIE) illuminant *C*. Measure the ratio of transmittance to incident luminous flux by calculating from the spectral distribution of illuminant *C* as defined by Practice E308.

## 8. Fabrication Requirements

8.1 All dimensional fabrication, such as cutting to overall dimensions, edgework, drilling, notching, grinding, sandblasting and etching, on laminates incorporating heat-strengthened, chemically strengthened, or fully tempered glass shall be performed prior to strengthening or tempering. After the glass

**TABLE 1 Maximum Allowable Laminating Process Blemishes for Vertical Glazing, in. (mm)**

NOTE 1—Refer to Specification C1036 for the quality specification for the individual glass lites.
NOTE 2—All imperfections noted should be separated by a minimum of 12 in. (300 mm).
NOTE 3—See 7.10 for method of inspection.
NOTE 4—Laminates with more than two lites of glass may contain proportionally more blemishes.

| Blemish | Up to 25 ft² (2.5 m²) | | 25 to 75 ft² (2.5 to 7.0 m²) | | Over 75 ft² (7.0 m²) | |
|---|---|---|---|---|---|---|
| | Central[A] | Outer[A] | Central[A] | Outer[A] | Central[A] | Outer[A] |
| Boil (Bubbles) | 1/16 (1.6) | 3/32 (2.4) | 1/8 (3.2) | 3/16 (4.8) | 1/4 (6.4) | 1/4 (6.4) |
| Blow-in; edge boil | [B] | CE 1/4 (6.4) EE 1/16 (1.6)[C] | [B] | CE 1/4 (6.4) EE 3/32 (2.3)[C] | [B] | CE 5/16 (8.0) EE 1/8 (3.2)[C] |
| Fuse | 1/32 (0.8) | 1/16 (1.6) | 1/16 (1.6) | 3/32 (2.4) | 3/32 (2.4) | 5/32 (4.0) |
| Hair, lint (single strand) | light intensity[D] | medium intensity[E] | light intensity[D] | medium intensity[E] | medium intensity[E] | medium intensity[E] |
| Inside dirt (dirt spot) | 1/16 (1.6) | 3/32 (2.4) | 3/32 (2.4) | 5/32 (4.0) | 1/8 (3.2) | 3/16 (4.8) |
| Lint-areas of concentrated lint | light intensity[D] | medium intensity[E] | light intensity[D] | medium intensity[E] | medium intensity[E] | medium intensity[E] |
| Separation, discoloration | none | none | none | none | none | none |
| Short interlayer; un-laminated area; chip | [B] | CE 1/4 (6.4) EE 1/16 (1.6)[C] | [B] | CE 1/4 (6.4) EE 3/32 (2.4)[C] | [B] | CE 1/4 (6.4) EE 1/8 (3.2)[C] |
| Scuff; streak | light intensity[D] | medium intensity[E] | medium intensity[E] | medium intensity[E] | medium intensity[E] | medium intensity[E] |

[A] The *central area* is an area formed by an oval or circle whose axes or diameters, when centered, do not exceed 80 % of the overall dimension. The *outer area* is the area outside of the *central area*.
[B] Not applicable.
[C] CE = covered edge of glass edge bite and EE = exposed edge. (If CE or EE is unknown use CE tolerance.)
[D] *light intensity*—Barely noticeable at 39 in. (1 m).
[E] *medium intensity*—Noticeable at 39 in. (1 m) but not at 10 ft (3 m).

has been strengthened or tempered, it shall not be modified except as recommended by the fabricator.

8.2 *Edge*—An edge shall be cut, sawed, ground, sanded to remove sharp edges only, seamed, ground and polished, beveled, or mitered as specified.

8.3 *Marking:*

8.3.1 Each laminate, as supplied by the manufacturer, shall bear the manufacturer's name, or trademark, or both, unless otherwise specified.

8.3.2 Laminated glass intended for safety glazing applications specified by building codes, shall be permanently marked as required by the applicable safety glazing standard.

8.4 *Thickness*—For thickness tolerances consult the laminator. Nominal thickness tolerance computation guidelines are as follows:

8.4.1 *Minimum Thickness Tolerance*—Minimum thickness tolerance shall be the summation of the values for the minimum thickness of each glass lite obtained from Specification C1036 and the minimum interlayer thickness obtained from the laminator.

8.4.2 *Maximum Thickness Tolerance:*

8.4.2.1 *Annealed Glasses*—The summation of the values for the maximum thickness of each glass lite obtained from Specification C1036 and the maximum interlayer thickness obtained from the laminator.

8.4.2.2 *Heat Treated Glasses*—Add 0.031 in. (0.79 mm) to the overall maximum thickness of the laminate for each lite of the heat treated glass in the laminate.

8.5 *Length and Width:*

8.5.1 Length and width tolerances of symmetrically laminated glass shall be in accordance with Table 3 when measured in accordance with 7.9. The listed tolerances of overall laminate size include the cutting tolerances of the individual lites as well as the mismatch of the glass lites after the laminating process.

8.5.2 For length and width of nonsymmetrical laminated glass, contact the supplier for size tolerances.

8.5.3 For some laminated applications, such as, point supported glass and balustrades, where the edges of the laminate are exposed, tighter length and width tolerances may be requested by the customer. Consult the supplier to determine their capabilities.

8.6 *Flatness:*

8.6.1 For laminated glass using annealed transparent glass, the overall bow and warp shall not exceed 1/16 in. (1.6 mm) per 12 in. (300 mm) of length when measured in accordance with 7.8.

8.6.2 Because of the nature of the processes used in manufacturing heat-strengthened, rolled, tempered, or wired glass, these glasses may not be as flat as annealed transparent glass.

**TABLE 2 Maximum Allowable Laminating Process Blemishes for Overhead Glazing, in. (mm)**

NOTE 1—Refer to Specification C1036 for the quality specification for the individual glass lites.
NOTE 2—All imperfections noted should be separated by a minimum of 12 in. (300 mm).
NOTE 3—See 7.10 for method of inspection.
NOTE 4—Laminates with more than two lites of glass may contain proportionally more blemishes.

| Blemish | up to 25 ft² (2.5 m²) | | 25 ft² or greater (2.5 m² or greater) | |
|---|---|---|---|---|
| | Central[A] | Outer[A] | Central[A] | Outer[A] |
| Boil (Bubbles) | 3/32 (2.4) | 1/8 (3.2) | 3/16 (4.8) | 1/4 (6.4) |
| Blow-in; edge boil | [B] | CE 1/4 (6.4)<br>EE 3/32 (2.4) [C] | [B] | CE 5/16 (8.0)<br>EE 1/8 (3.2)[C] |
| Fuse | 1/16 (1.6) | 1/16 (1.6) | 3/32 (2.4) | 5/32 (4.0) |
| Hair, lint (single strand) | medium intensity[D] | medium intensity[D] | medium intensity[D] | medium intensity[D] |
| Inside dirt (dirt spot) | 3/32 (2.4) | 3/32 (2.4) | 5/32 (4.0) | 3/16 (4.8) |
| Lint-areas of concentrated lint | medium intensity[D] | medium intensity[D] | medium intensity[D] | medium intensity[D] |
| Separation, discoloration | none | none | none | none |
| Short interlayer; un-laminated area, chip; | [B] | CE 1/4 (6.4)<br>EE 3/32 (2.4)[C] | [B] | CE 1/4 (6.4)<br>EE 1/8 (3.2)[C] |
| Scuff; streak | medium intensity[D] | medium intensity[D] | medium intensity[D] | medium intensity[D] |

[A] The *central area* is an area formed by an oval or circle whose axes or diameters, when centered, do not exceed 80 % of the overall dimension. The *outer area* is the area outside of the *central area*.
[B] Not applicable.
[C] CE = covered edge of glass edge bite and EE = exposed edge. (If CE or EE is unknown use EE tolerance.)
[D] *medium intensity*—Noticeable at 39 in. (1 m) but not at 10 ft (3 m).

**TABLE 3 Length and Width Tolerances for Rectangular Shapes of Symmetrically Laminated Glass Including Mismatch[A]**

| Laminate Thickness Designation, *t* in. (mm) | Tolerances, in. (mm)[B,C] | | |
|---|---|---|---|
| | Transparent Glass | Patterned and Wired Glass | Heat Strengthened and Tempered Glass |
| t ≤1/4 (t ≤6.4) | + 5/32, –1/16 (+4.0, –1.6) | + 5/16 –1/8 (+7.9, –3.2) | +7/32 –3/32 (+5.6, –2.4) |
| 1/4 < t ≤ 1/2 (6.4 < t ≤ 12.7) | + 1/4, –1/16 (+ 6.4, –1.6) | + 5/16, –1/8 (+ 7.9, –3.2) | + 1/4, –1/8 (+ 6.4, –3.2) |
| 1/2 < t ≤ 1 (12.7 < t ≤ 25.4) | +1/4, –1/8 (+ 6.4, –3.2) | +5/16, –1/8 (+ 7.9, –3.2) | +5/16, –1/8 (+ 7.9, –3.2) |

[A] For nonsymmetrical laminated glass, contact the laminator for size tolerances.
[B] Size includes cutting and fabrication tolerances and mismatch (see 8.5.1).
[C] For exposed edge applications, consult the supplier to determine their capabilities.

The deviation from flatness of laminated glass depends on glass type, thickness, width, length, laminating process, and other factors. For other than annealed transparent glasses the overall bow/warp shall not exceed the values shown in Table 4 when measured in accordance with 7.8.

8.6.3 Localized warp for rectangular laminated glass shall not exceed 1/16 in. (1.6 mm) in any 12 in. (300 mm) span of edge.

8.7 *Blemishes*—Maximum allowable laminating process blemishes shall not be greater than those listed in Table 1.

## 9. Keywords

9.1 annealed; blast resistant; bullet resistant; glass; heat-treated; hurricane resistant; interlayer; laminated; safety; security

**TABLE 4 Maximum Allowable Overall Bow and Warp for Laminated other than Annealed Transparent Glasses[A]**

| Edge Dimension, in. (mm) | Laminate Make-up Two Glass Lites of, in. (mm): | | | | |
|---|---|---|---|---|---|
| | 1/8 to 3/16 (3 to 5) | 1/4 (6) | 5/16 (8) | 3/8 (10) | 1/2 to 7/8 (12 to 22) |
| 0 to 18 (0 to 460) | 1/8 (3.2) | 1/16 (1.6) | 1/16 (1.6) | 1/16 (1.6) | 1/16 (1.6) |
| Over 18 to 36 (Over 460 to 910) | 3/16 (4.8) | 1/8 (3.2) | 3/32 (2.4) | 3/32 (2.4) | 1/16 (1.6) |
| Over 36 to 48 (Over 910 to 1220) | 9/32 (7.1) | 3/16 (4.8) | 5/32 (4.0) | 1/8 (3.2) | 3/32 (2.4) |
| Over 48 to 60 (Over 1220 to 1520) | 3/8 (9.5) | 9/32 (7.1) | 7/32 (5.6) | 3/16 (4.8) | 1/8 (3.2) |
| Over 60 to 72 (Over 1520 to 1830) | 1/2 (12.5) | 3/8 (9.5) | 9/32 (7.1) | 1/4 (6.4) | 3/16 (4.8) |
| Over 72 to 84 (Over 1830 to 2130) | 5/8 (15.9) | 1/2 (12.7) | 11/32 (8.7) | 5/16 (7.9) | 1/4 (6.4) |
| Over 84 to 96 (Over 2130 to 2440) | 3/4 (19.0) | 5/8 (15.9) | 7/16 (11.1) | 3/8 (9.5) | 9/32 (7.1) |
| Over 96 to 108 (Over 2440 to 2740) | 7/8 (22.2) | 3/4 (19.0) | 9/16 (14.3) | 1/2 (12.7) | 3/8 (9.5) |
| Over 108 to 120 (Over 2740 to 3050) | 1.0 (25.4) | 7/8 (22.2) | 11/16 (17.5) | 5/8 (15.9) | 1/2 (12.7) |
| Over 120 to 132 (Over 3050 to 3350) | ... | 1.0 (25.4) | 13/16 (20.6) | 3/4 (19.0) | 5/8 (15.9) |
| Over 132 to 144 (Over 3350 to 3660) | ... | 1 1/8 (28.6) | 15/16 (23.8) | 7/8 (22.2) | 3/4 (19.0) |
| Over 144 to 156 (Over 3660 to 3960) | ... | 1 1/4 (31.8) | 11/16 (27.0) | 1.0 (25.4) | 7/8 (22.2) |

[A] See 7.8 for measurement method.

# APPENDIX

## (Nonmandatory Information)

## X1. GLASS SELECTION

X1.1 *Visual Mockups*—Viewing full-size mockups under typical site conditions and surrounding landscape is highly recommended for evaluation of reflected and optical distortion.